Chapter 7

THE FRAMEWORK: STANDARDS 1-5

(The Process Standards)

INTRODUCTION

In the introductory statement that accompanies New Jersey's *Core Curriculum Content Standards*, standards are described as "what students should know and be able to do in specific academic areas and across disciplines." The twelve *Science Standards* can easily be separated into two equally important categories that reflect this description.

Science Standards 6 through 12, while providing for the development of investigative skills, basically serve to define what students should know about life, physical, earth, and environmental science and can be referred to in the strictest sense as "content standards." *Science Standards 1 through 5*, however, speak in a more general sense to the nature of science and scientific inquiry. These five "process standards" address not only what students should be able to do as they learn and practice any science but also what they should know and understand about the interaction of science with the human experience—both now and in the past.

This chapter discusses each of those first five standards, emphasizing their necessary role in an effective science program. A careful examination of each process standard and the cumulative progress indicators (CPIs) that accompany it will leave the reader with a clear sense of its importance and meaning.

Chapter 8 of the *New Jersey Science Curriculum Framework* features hundreds of learning activities that illustrate the seven content standards. These activities have been cross-referenced to the five process standards. As teachers experiment with the suggested activities, they will quickly see the meaningful integration of science content and the evolution of process skills.

The purpose of this chapter, then, is to provide a concise overview of the five interdisciplinary process standards, which are cited throughout chapter 8 where they relate to the sample learning activities.

SCIENCE STANDARD 1

All students will learn to identify systems of interacting components and understand how their interactions combine to produce the overall behavior of the system.

If we define a *system* as a group of parts interacting together to function as a whole, then the study of science at all grade levels will involve the study of systems. The purpose of this standard is to have students identify systems—those that exist in nature and those that are designed and built by humans—and to be able to understand the interactive relationships between the parts and the whole. Whether it be life, Earth, or physical science, learners will discover systems inherent in the natural world, such as ecosystems, the water cycle, the solar system, or physical systems in equilibrium. They will also encounter those systems that have been engineered by humans, such as a transportation system, electrical systems, or even social systems. In each case, understanding how the components work together is essential to an understanding of the system.

Younger students will, at first, focus on identifying the parts of a system before progressing to the realization that manipulating the parts can and will affect the whole. As they begin to recognize these interactions, they develop a sense of *input* and *output* as well as the idea of *feedback*, particularly in system design. Eventually, they come to see that systems within systems can exist and interact with each other. In addition to studying the increasingly complex systems and cycles found in nature, older students should be encouraged to experiment with the design and construction of model systems. The sample learning activities provided in chapter 8 for the science content standards include examples of natural and constructed systems. In particular, students should have the opportunity to participate in system design and analysis on a regular basis.

SCIENCE STANDARD 2

All students will develop problem-solving, decision-making, and inquiry skills, reflected by formulating usable questions and hypotheses, planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions, and communicating results.

While no attempt has been made to rank New Jersey's *Science Standards* in order of importance, most science educators would agree that a paramount goal of any science program would be the development of those skills used by scientists as they conduct investigations and share the results of those investigations with others.

To implement this standard, students must be exposed early on to science as a "hands-on, minds-on" process, encouraged to explore the world around them with all of their senses and a curious, open mind. As students grow, observation and exploration become the basis for planning and conducting experiments. These activities, in turn, lead to an understanding of the role of variables and the methods used to analyze and interpret data. At every age, students are taught how to organize and present their findings. The ultimate intent of this process standard is to produce scientifically literate graduates capable of thoughtful analysis and informed decision making in the workplace, supermarket, or voting booth.

Within the *New Jersey Science Curriculum Framework*, it will be readily apparent that, without exception, the sample learning activities presented reflect and support the intent of this all-important science standard.

It would be impossible today for educators to find a science program or textbook that does not stress the importance of the skills addressed by this standard. Both the *National Science Education Standards* and *Benchmarks for Scientific Literacy* devote several chapters to their development. We urge readers of this *Framework* to refer to either or both of these excellent resources for further discussion.

SCIENCE STANDARD 3

All students will develop an understanding of how people of various cultures have contributed to the advancement of science and technology, and how major discoveries and events have advanced science and technology.

Curiosity is a human trait and, therefore, science is a human endeavor. Virtually all cultures have recorded their attempts to make sense of the world they live in, and this has provided science with a rich and fascinating history. To fully appreciate today's scientific achievements, students must learn that our present-day theories emerged over time, are based on the contributions of many, and will, in turn, be replaced by tomorrow's discoveries.

While the best place to begin implementing this standard with younger students is by providing them with a good story, the standard should be seen as more than simply a directive to supplement science instruction with anecdotal references to people and events. Rather, the intent is threefold:

- To show students that scientific ideas and theories have a history of their own by tracing the evolution of our most important present-day paradigms
- To fully integrate the impact of scientific and technological advances—and the people who made them—in each student's understanding of history
- To present science as an ongoing human activity, contributed to by people of all cultures, subject to inherent limitations, and influenced by the social and political climates of the time

Once again, the reader is referred to *Benchmarks* for *Scientific Literacy* (chapter 10) for a discussion of the major events in the history of science.

SCIENCE STANDARD 4

All students will develop an understanding of technology as an application of scientific principles.

Throughout history, science and technology have enjoyed a unique, interdependent relationship. Today, the word *technology* means many things to many people. In the field of education, it conjures up images of computers in every classroom and every classroom connected to the Internet. A successful science program should indeed have available modern communications technology, and in fact, *Science Standard 2* clearly calls for students to develop the skills needed to utilize this technology.

Science Standard 4, however, is not designed to address the need for classroom technology. Rather, the purpose of this standard is to have students appreciate the intimate relationship between science and technology and (more importantly) to combine hands-on technology and design skills with the learning of scientific principles. This merger of technology education and science education is examined in detail in chapter 6.

SCIENCE STANDARD 5

All students will integrate mathematics as a tool for problem solving in science, and as a means of expressing and/or modeling scientific theories.

Even more obvious than the link between science and technology is the intimate relationship between science and mathematics. Science cannot be practiced, taught, or learned without the usefulness of mathematics as a language and an essential problem solving tool. *Benchmarks for Scientific Literacy* consistently refers to mathematics as just one of many “other sciences.” Therefore, as students deal with increasingly complex scientific concepts, they will rely more heavily on their mathematical skills. Indeed, their ability to study more advanced physical theories will ultimately depend on their level of mathematical sophistication. A developmental overview of those skills can be found in the *New Jersey Mathematics Curriculum Framework*. The total integration of those skills with the learning of science is the intent of this standard.

From the earliest grades, students should find science and mathematics virtually indistinguishable. Beginning with counting, young students will progress quickly to making simple measurements (introducing them to units), which will lead, in turn, to collecting and displaying data. In the middle and upper grades, students should consistently be asked to use mathematics to analyze and interpret experimental results, determining relationships among variables, and deriving mathematical expressions that describe physical phenomenon. At the most challenging level, they should begin to appreciate the importance of a mathematical model as a valid representation of an otherwise unobservable entity.